THURSDAY, OCTOBER 14, 1886

SCIENTIFIC WORTHIES

XXIV.—John Couch Adams

PROFESSOR J. C. ADAMS, whose portrait we this day present to our readers, entered St. John's College, Cambridge, in 1839. He soon gave promise of those great mathematical powers that have brought such renown to his University. He came out as Senior Wrangler in 1843, and the excellence of his answering is still a tradition at Cambridge.

By what seems to have been an inspiration of genius, he was guided after taking his degree to concentrate his talents on the solution of an astronomical problem of excessive interest but of corresponding difficulty. The planet Uranus had shown irregularities in its motion. The orbit differed from the elliptic path which an undisturbed planet would pursue, and the deviations could not be fully accounted for by the influences of the other known planets. The only explanation of the discrepancy which astronomers could be expected to favour lay in the supposition that there was some other still more remote planet yet unknown.

It was the search for this unknown planet which attracted the distinguished Senior Wrangler. We can imagine the delight with which a well-equipped mathematician would throw himself into the solution of such a problem. On it he was to concentrate the powers that had been cultivated during his University career.

The planet was to be sought for by the measured deviations of Uranus from its calculated positions. Those who have ever had occasion to study the planetary theory are well aware of the difficulty and the laborious intricacy of the subject. To most of us it has seemed a thorny and difficult problem when the planet is given to find the perturbations. What are we to say of the difficulty of the converse problem, Given the perturbations and find the planet! This was the problem which Adams faced, and which, to his imperishable fame, he succeeded in solving. The story of this discovery is familiar to all, and the controversies that arose have long since died away. To each of the joint discoverers, Leverrier and Adams, the gold medal of the Royal Astronomical Society was presented on February 11, 1848. In his address on the occasion, Sir John Herschel, speaking of the two astronomers, says:—

> "M. Leverrier and Mr. Adams—names which as genius and destiny have joined them, I shall by no means put asunder; nor will they ever be pronounced apart so long as language shall celebrate the triumphs of Science in her sublimest walks. On the great discovery of Neptune, which may be said to have surpassed, by intelligible and legitimate means, the wildest pretensions of clairvoyance, it would now be quite superfluous for me to dilate. That glorious event and the steps which led to it, and the various lights in which it has been placed, are already familiar to every one having the least tincture of science. . . . I will only add that as there is not nor henceforth ever can be the slightest rivalry on the subject between these two illustrious men—as they have met as brothers, and as such will, I trust, ever regard each other—we have made, we could make, no distinction between them on this occasion. May they both long adorn and augment our science, and add to their own fame, already so high and so pure, by fresh achievements."

The discovery of Neptune was a brilliant inauguration of the astronomical career of Adams. We cannot here enter into a detailed account of his numerous labours. There is an admirable account given of them up to the year 1866 in the address of Mr. De la Rue to the Royal Astronomical Society, when Adams was again the recipient of a gold medal. We find that he has worked at and written upon the theory of the motions of Biela's comet; he made important corrections to the theory of Saturn; he made an elaborate investigation of the mass of Uranus, to which he was naturally attracted from its importance in the theory of Neptune; he has improved the methods of computing the orbits of double stars: but next to the discovery of Neptune the fame of Adams mainly rests on his researches on the moon and on the theory of the November meteors. To each of these subjects we must devote some attention.

In the *Phil. Trans.*, vol. cxliii. part iii. p. 397, his paper was published "on the secular variation of the moon's mean motion." This memoir originated a long controversy, in which the ablest mathematicians have participated.

The "secular acceleration of the moon's mean motion" is the phrase which denotes a gradual but excessively slow diminution in the moon's periodic time. Although the amount of this diminution is very minute, yet the fact that it always tended in the same direction rendered the amount accumulative, so as to become very perceptible in the succession of ages. The explanation of the acceleration formed a problem on which the great mathematicians at the close of the last century exercised their powers, and at length the explanation was given by Laplace. He found that, when the analytical expression for the moon's mean motion was developed, it contained certain terms depending upon the eccentricity of the earth's orbit. This eccentricity varies in consequence of the planetary perturbations, and hence the changes of the moon's mean motion. Laplace calculated the amount, and deduced, or thought he had deduced, a correspondence between the observed value and the calculated value. The high authority of Laplace, and the brilliant success of his efforts to explain other perturbations in our system, led to an acquiescence in his results, and the great problem of the secular acceleration was believed to have been solved.

In Mr. Adams's paper he joined issue with Laplace. The question was fortunately one which did not involve any real element of uncertainty. It was a problem in mathematics, or rather dynamics—difficult no doubt, but not really open to any ambiguity. Prof. Adams showed that Laplace had only considered a part of the disturbing influence, and when the true amount was determined, it came out to be only about one-half that found by Laplace. So serious a charge received the careful consideration which it merited. Several leading mathematicians impugned the calculations of Adams, but he was able to vindicate his theory at every point, and finally the correctness of his calculations was verified in one manner by M. Delaunay, and in another by Prof. Cayley. The importance of this result is not to be estimated merely by its value as a correction to Laplace. The author of the "Mécanique Céleste," like other writers, makes errors in his work. Numerous errors have been detected by Laplace's commentators, but the secular acceleration occupies quite a distinct position. It must be remembered that the calculations of Laplace appeared to render a physical explanation of a remarkable phenomenon. But when this calculation was shown to be seriously wrong, it followed that the cause of the secular acceleration conjectured by Laplace was inadequate to explain the observed facts. The labours of Adams thus reopened the breach between the observations and the theory. The variations in the eccentricity of the earth's orbit will account for part of the secular acceleration. The other part has to be accounted for in a different way. The theory of the tides seems to offer an explanation of the discrepancy. Owing to their incessant action the period of the diurnal rotation has been slightly elongated, and this effect, when duly taken account of, seems to remove the margin between the theoretical and observed values of the secular acceleration. This margin has indeed a singular interest in the recent theory of tidal evolution, inasmuch as it affords us the only measurable indication we have of the effect of tides on the earth's rotation.

The splendid shower of shooting-stars that occurred in November 1866 fixed the attention of astronomers on every part of the theory of these bodies. We were thus taught much concerning them, but for one of the most recondite parts of their theory we are indebted to the labours of Prof. Adams. It had been known that the great displays of the Leonids (for so these shooting-stars are called) take place every thirty-three years. From the year 902 down to the year 1866 many of the successive thirty-three-year periods witnessed the great shower, and records of a considerable number have been handed down to us.

These minute bodies must revolve around the sun, each pursuing its orbit in accordance with the laws of Kepler. It became of interest to find the size and shape of this orbit, as well as its position. Certain features of the orbit are readily determined. The recurrence of the shower on a particular day of the year gives one point in the path of the meteors. The direction of the radiant gives a tangent to that path, and therefore its plane. The sun, of course, lies at the focus, and only a single further element—the periodic time—is requisite to complete our knowledge of the orbit. We are indebted to Prof. H. Newton, of Yale, for his careful discussion of this subject. He had shown that the choice of possible orbits was limited to five. There was first the great oval orbit, in which we now know the meteors do revolve every 33¼ years. There was next a nearly circular orbit, with a periodic time a little more than a year; another similar orbit, in which the periodic time would be a few days short of a year; and there were also two other smaller orbits. Prof. Newton had also indicated a method by which it would be possible to discriminate the true orbit as one of these five. The mathematical difficulties of this method were no doubt great, but they did not baffle Prof. Adams.

In the *Monthly Notices* for April 1867, p. 247, will be found the paper in which he announced his solution of the problem. The orbit of the meteors is not fixed, but every time the great swarm comes round, the node is found to be 29 further on in the direction of motion. The effect of this is shown in the gradual alteration of the date of recurrence of the shower. The only influence known to us which could account for this change of the plane, is the attraction of the other planets. The problem, then, may be placed in this shape. A certain specific amount of change of the node takes place. The theoretical change can be computed for all the five different orbits, and Prof. Adams undertook to find it. The difficulty principally arises from the high eccentricities of some of the orbits, which rendered the more familiar methods of calculation inapplicable. After many months of labour, Prof. Adams, aided by his assistants in the Cambridge Observatory, completed his work. He showed that if the meteors revolved in the large orbit with the periodic time of 33¼ years, the perturbations of Jupiter would account for a change to the extent of 20′. The attraction of Saturn would augment this by 7′, and Uranus would add 1′, the effect of the earth and the other planets being insensible. The joint effect is thus 28′, which may be regarded as practically coincident with the observed value determined by Prof. Newton. The great orbit was thus a possible path for the meteors, but to complete his discovery Adams had to show that neither of the other four orbits could experience the same perturbation. This, too, he succeeded in demonstrating: he showed that in no one of the other orbits could the change exceed 12′. Thus the orbit of the Leonids was discovered.

Those tremendous powers of calculation which have been exercised on the heavenly bodies with such signal results have also been occasionally applied in various other directions. The discoverer of Neptune has found relaxation from the labours of physical astronomy by little calculations on which we must gaze with astonishment. He has had the curiosity to compute the sums of the reciprocals of the first thousand numbers to 260 places of decimals. We have such confidence in the accuracy of Prof. Adams that we have not thought it necessary to repeat this calculation! He has also taken the trouble to calculate thirty-one of Bernouilli's numbers beyond the point that previous calculators had attained, and he has expressed each of them both as vulgar fractions and as decimals. The sixty-second Bernouilli, the last computed by Adams, runs to 111 places, where fortunately for astronomy the appearance of a recurring figure has terminated this inquiry.

Need it be added that on Prof. Adams every honour which science can bestow has been conferred. We have now the pleasure of enriching our list of Scientific Worthies by the addition of his portrait. R. S. B.

THE BRITISH MUSEUM BIRDS

Catalogue of the Birds in the British Museum. Vol. XI. Fringilliformes: Part II. Containing the Families *Cœrebidæ*, *Tanagridæ*, and *Icteridæ*. By Philip Lutley Sclater. (London: Printed by order of the Trustees. 1886.)

DR. GÜNTHER and the authorities of the Natural History Department of the British Museum are to be congratulated, first, on having sought, and next on having secured, the services of Mr. Sclater for the execution of the eleventh volume of their "Catalogue of Birds." The principal group of which it treats is one that has been, for five-and-thirty years or more, the